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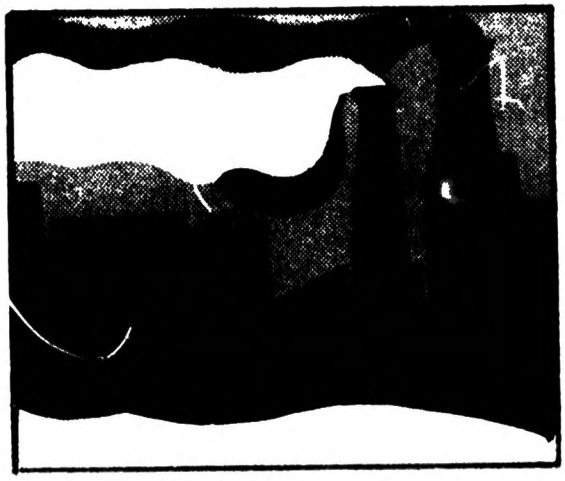
ABSTRACT

This teaching guide is designed to be used with secondary school students and the unit Air Pollution and Your Health. Material for the teacher includes the following: (1) an introduction to the unit; (2) a discussion of the sections of the unit; (3) instructional objectives; (4) suggestions for use of filmstrips, worksheets, reference materials, and activity cards; and (5) an outline of the unit. These materials have been validated as successful, cost-effective, and exportable by the standards and guidelines of the U.S. Office of Education. (RH)

PRIORITY ONE
ENVIRONMENT

AIR POLLUTION AND YOUR HEALTH



PRIORITY ONE
environment

POLLUTION CONTROL EDUCATION CENTER
Township of Union Public Schools
Union, New Jersey

AIR POLLUTION AND YOUR HEALTH

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AIR POLLUTION AND YOUR HEALTH

AIR POLLUTION AND YOUR HEALTH

CONTENTS

INTRODUCTION TO THE UNIT
AIR POLLUTION AND YOUR HEALTH

Significant steps for improving the quality of the air in America have been taken in recent times by government agencies, educational institutions, and conservation groups. While these groups have done much good, it is still true that the average American citizen is faced with health hazards from polluted air as well as with general loss of environmental quality both in esthetic and economic terms.

Air pollution is a social problem, a problem which stems from conflicting values in our population. If young people today are to be prepared for making sensible air-quality decisions, then they need to know what the alternatives, choices, and consequences are. They must learn that every air pollution "solution"—such as emission control devices for the automobile, or clean-burning fuels for industries and power plants—involves scientific, political, and economic factors. Young and old alike, all citizens, need an awareness of how vulnerable we have become in an interdependent society. For example, one out of every seven workers has a job in some way related to the continuing use of the automobile. Changes in the economy or in our uses of energy can directly affect everybody's life.

In this unit, ***an interdisciplinary approach*** to understanding and correcting air pollution has been designed, for two reasons: First, either science, language arts, or social studies teachers can teach the unit by themselves, or they can work together to team teach the unit. Second, all the critical environmental questions of our time, one of which is ***how clean do we really want the air to be***, will best be answered by a ***cooperative pooling of information*** supplied by researchers, technologists, communications experts—and, ultimately, by consumers.

Section I — **Clarifying Issues and Values** personalizes the cause-effect of air pollution with an introductory filmstrip and an episode in values clarification; in this first section the private passenger car is singled out as the foremost source of air pollution, and students are engaged in activities which encourage evaluation of the automobile and its use.

Section II — **Examining the Facts Today** presents the other causes of air pollution and provides for investigations into the many effects of polluted air, particularly as concerns human health; this section begins and ends with in-class experiments that the teacher will want to prepare for in advance.

Section III — **Prevention Technology** identifies and describes some modern methods for reducing or eliminating the pollutant gases and particulates that occur during the combustion processes in industries, power plants, and motor vehicles.

Section IV **What Is the Law? Is It Working?** goes from a consideration of the role of legislation, with information about the Clean Air Act of 1970, to an appraisal of the implementations and non-implementations of the law at this time; in this final section reference is made also to the role of citizen action in pollution prevention and to the need for citizen awareness of local and national trends in legislation, research, and general air quality.

INSTRUCTIONAL OBJECTIVES

The developers of *Priority One: Environment* have recognized student input as essential to structuring significant learning experiences. The materials in this unit, *Air Pollution and Your Health*, have been student and teacher-tested in the development stages. The education objectives of the unit, as specified below, are correlated with a twenty-question multiple-choice test. It has been provided for your use on two of the Ecomasters. Answers to the test appear on page 24 of this Guide.

We recommend that you administer the unit test to each of your students before and after using this unit so that you can measure the growth in learning that the field-testing of each *Priority One* unit has shown to take place. Further inquiry concerning evaluation procedures and designs can be made directly to the **Pollution Control Education Center, Union Township Board of Education, Union, New Jersey.**

At the end of this unit, the student will be able to:

1. Name the five major sources of air pollution in the United States.
2. Correlate each of the five major sources with the specific pollutants currently being produced by them.
3. Identify ***incomplete combustion*** as the main reason for pollution from these major sources.
4. Describe at least one episode, or crisis, of an air pollution condition prior to 1970.
5. Specify at least four contemporary statistics about the environmental and/or economic impact of the private passenger automobile in America.
6. Make at least two observations about local automobile use based on empirical findings.
7. Describe the effects of ***carbon monoxide*** and ***nitrogen oxides*** on the human body.

8. Describe the effects of ***sulfur dioxide*** and ***particulates*** on the human body.

9. Set up and run an experiment to determine which home-heating fuel (coal, oil, or natural gas) could cause the most air pollution.

10. Set up and run experiments to test the effects of polluted air (1) on seedlings; (2) on nylon; and (3) on rubber.

11. Describe the operation of at least two pollution control technologies which industry can implement.

12. State at least one argument in favor of using the catalytic converter to curb pollutant emissions from the automobile and one argument against its use.

13. Name the three federal milestones in air pollution legislation and briefly describe at least one of them.

14. Identify at least two reasons why the Clean Air Act of 1970 was not fully implemented by 1976.

15. List at least three provisions which he or she thinks have been or should be built into air pollution at (1) the local level; (2) the state level; and (3) the federal level.

16. Monitor the local community for clean air; specifically, to evaluate local air pollution ordinances, citizen opinion and activism, and on-going media reports.

SECTION I CLARIFYING ISSUES AND VALUES

FOCUS

It is suggested that the teacher introduce this unit on air pollution with a showing of the first filmstrip, **A Story of Air Pollution**, followed by use of the values clarification material in the Preface to the **Student Resource Booklet**. This sequence can be expected to provide a framework for your students as they begin to evaluate air pollution in terms of cause and effect, as well as in terms of prevention and control. As the values framework builds, each student will be identifying specific air pollution questions that he or she would like to have answered as the unit progresses (**Worksheet 1**). Some of your pupils will choose to monitor the impact of the automobile on your local area (**Activity Cards 1 and 2**) and, hopefully, share their findings with the class. Common to all of the activities in Section I, whether your students are sharing observations that they have made about *themselves as individuals*—drawn from the **Preface to the Unit**—or reacting in group discussion to the article, **The Future of the Automobile**, is the fact that your class will encounter air pollution issues in a human arena. As the needs and priorities of people come into view, they will be seen to reflect the larger society which contains us all.

Additional information which the teacher may find useful in discussions about the automobile has been supplied in this section of the Guide. The **Synopsis of Federal Highway Legislation** provides data on how federal money for road-building has increased the use of motor vehicles above all other forms of transportation combined.

The developers of this unit encourage the teacher to feel that there are few "right answers" for you and your class to zero in on as you clarify the issues and values in Section I. Air pollution—like water pollution, land use, vanishing species, and garbage disposal—is largely a problem of conflicting values. Your students will really need more time to sort out and shape their values than Section I provides. They will want to know what other people value, and why. They will need to learn what practical choices we have as a society in order to improve the quality of the air we breathe. If you conduct Section I primarily for values orientation, then Sections II, III, and IV will be useful for the gathering of relevant information. Then a return to the values thrust would be appropriate if you like, for purposes of summing up and making value judgments.

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
Preface to the Unit, Seeing Issues as Human Values **The Future of the Automobile**	**Filmstrip 1** A Story of Air Pollution **Audio Cassette Side A**	**Worksheet 1** Air Pollution Problems **Worksheet 2** Automobile Air Pollution	**Activity Card 1** Computing Automobile Pollution **Activity Card 2** Estimating the Carbon Monoxide in Your Area

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Filmstrip – A Story of Air Pollution As you introduce this unit by showing the filmstrip, the students will learn both the characteristics and the composition of Earth's atmosphere. They will learn, for example, that half of all the air we breathe is within a three-and-one-half mile zone that surrounds the Earth, and 99% of the atmosphere is within a twenty-five mile zone. They will learn too that our atmosphere has self-cleansing properties, due to motion and condensation. The filmstrip identifies the importance of permanent and variable gases in the atmosphere, and defines **air pollution** as an unbalanced, or unnatural, mixture of gases and particulates which the self-cleansing properties cannot restore to natural balance. A brief history of air pollution is given, and the student is introduced to the fact that much of the air in urban areas today is unhealthful to breathe, that the average resident of New York City, for example, "takes into his lungs the pollution equivalent of 37 cigarettes a day."

Worksheet 1 – Air Pollution Problems and Booklet Article – Preface to the Unit

Distribute copies of the first worksheet as students discuss the filmstrip. The worksheet encourages students to write down five (or more) questions that they would like to have answered during the course of the unit. Since a key consideration about polluted air is its effect on people's health, you might like to recommend that one of the questions concern human health. Give the students a day or two to frame their questions, and let them know that they will have a discussion about their questions–and the answers which they did (or did not) get–at the end of the unit.

The back of **Worksheet 1** can be used for the next activity, which is in the **Student Resource Booklet**. The first part of this activity in values clarification–the rank ordering which each student is asked to do for ten items given in the Preface–can be done either in class or at home. It would probably be helpful, though, to have the activity done in class, if time permits, with yourself available as a resource person to answer typical questions that will arise, such as for number 3, "Where would forestry (or fashion design) go?" You can then say, "Helping to get facts" (or "Helping to deliver the goods and services") etc. For numbers 7 and 8, should a student ask, "What is the Nature Conservancy?" you should know that it is a citizen-action organization for land preservation. By 1970, the Nature Conservancy had members and chapters in every state and had preserved 150,000 acres of land from development–146,000 of those acres representing 41 different states within the past twenty years. Fielding the other questions is up to you!

The next step is for students to draw some conclusions based on their own value judgments. This part of the activity can be handled in a variety of ways. Choose whatever you think is appropriate for your class. Students can continue to work independently, and a whole-class pooling of rank orders can be tallied when everybody is finished, followed by a sharing of observations by those who wish to participate. Or, to provide the students with more information concerning "the society of which you are a part" reference that is made in their booklets, you can let them get into groups of four or five (or choose the groups yourself). Then the groups can discuss how and why they rank-ordered the items as they did, and come up after an appropriate period of idea-sharing **either** with individual-based conclusions **or** group-based conclusions. A step beyond this would be the designation by each group of a spokesman who would orally present his group's consensus to the class.

Worksheet 2 – Automobile Air Pollution

Before your students read and discuss the booklet article, **The Future of the Automobile**, hand out copies of the second worksheet, **Automobile Air Pollution**, which will require them to interview twelve automobile owners, four who own large cars, four who own medium size cars, and four who own small cars. The students may need a day or two in order to plot the bar graphs for Graph B and to answer the four questions on the worksheet, based on information which the twelve automobile owners must supply. Be sure the students understand that a large car, generally speaking, is one which weighs over 5,000 pounds; a medium size car weighs between 3,000 to 5,000 pounds, and a small car weighs less than 3,000 pounds. Whenever the students bring their completed worksheets to class (either after you have discussed the booklet article or at any convenient time in Section II), ask a student volunteer to put his or her Graph B on the chalkboard and answer Question 1. Ask the class whether their charts differ significantly from the one on the chalkboard, and, if so, why.

You may also want to list on the chalkboard the answers your students have obtained to Question 2. As potential automobile drivers or owners, they should be aware of how they can modify the amount of pollution caused by vehicles which they may drive. Typical answers should include these: avoid short trips, accelerate moderately from a stop, keep the car well tuned, and use small cars. Answers which the students get to Questions 3 and 4 will be further defined in Section III of this unit, where emission control technology for the automobile is explained.

Booklet Article – The Future of the Automobile

There are several points to emphasize in class discussion about this article. First is the extent to which the use of motor vehicles in general and the private passenger car in particular dominates contemporary American life. The dominance can be seen in our economy, since one out of every seven employed Americans holds a job that is related to the use of the automobile. The dominance can also be seen in the growing phenomenon called suburban life and in the extensive federal support of road-building. Since your students have had some experience with values clarification by this time in the unit, they should be able to see that the article refers to the conflicting values that exist concerning the use of the automobile.

If, having read the article, a student should ask you how many gas station employees and how many motels there are today, compared to the numbers given for 1967, feel comfortable to tell the asker that both figures have grown one and one half times since then. You can then ask the student to compute the current figures for the class; i.e., there are over 11,000,000 gas station employees and over 76,000 motels in the United States at the present time.

Do your students agree or disagree with the statement made in the article that Americans' use of leisure time seems to indicate that the automobile is here to stay? How many of them travel by car on vacation? How many like to go camping in a recreational vehicle with an enticing name such as *Wanderer* or *Discoverer*, and with interior decor billed as *Glacier, Sequoia, Canyon Lands*, or *Painted Desert*? (Actually, a study of motor vehicle advertising is an interesting topic in itself.) Do any of your students look through the ads to see what new models and what new options are available to potential customers? What do they think about slogans like "Drive a Datsun—Plant a Tree" to attract the ecologically-minded customer? (Recently Datsun had offered to plant a tree for every car they sold.)

Students can eventually be expected to ask the nitty-gritty questions such as, "Just what *is* a planned community of non-commuters?" and "What alternatives (to the private passenger car) *are* there for suburban-to-city commuters?" The equivalent of twelve cities, each containing a population of 250,000 or more, are developed in the United States every year. Most of these are add-ons to existing urban areas, usually transformations from suburban conditions. Some planners feel that the deliberate creation of new cities can arrest urban sprawl and reduce problems of pollution and traffic congestion as well. Other people, however, feel that the idea of self-containment—meaning a small area wherein people live, work, and play—is an impossible dream. The first group describe Vallingby and Farsta in Stockholm, and Tapiola in Finland, as good examples for the United States to follow. The second group describe Reston, Virginia, and Columbia, Maryland, as examples that have been tried in the United States and have failed, since they were swallowed up in the urban area of Washington, D. C. anyway. And yet, more self-contained cities are coming into operation in the world today—in Brazil, Pakistan, and Venezuela, for example. It still remains to be seen if a model, or example, that seems to work elsewhere will also work in the United States.

See if any of your students have some creative ideas on how mass transit can be improved for the suburban-to-city commuter. The monorail, as illustrated in their booklets, is a favored contemporary design. So too is the use of a network of rental cars. The average car is expensive to own and run; it also is parked more than twenty hours a day. Imagine a low-rental, low-speed, low energy-consuming, recyclable automobile available on demand! *(That's an environmentalist's dream! The information which follows concerns impetus given to the use of the automobile by federal legislation.)*

Synopsis of Federal Highway Legislation

Most cities by the early 1900's had brick, concrete, or asphalt paving, but there were only 500 miles of paved rural roads in the United States in 1910. Therefore, the first federal legislation to promote road building, in 1916, was aimed at getting the farmer out of the mud. Federal monies were made available to the states as each separate rural-to-city road building proposal was approved. In 1921, a new law required that all roads built with government subsidy had to be "main connecting" roads between cities, counties, and even states. Both laws provided federal money for 50% of the total cost of the roads. Until 1941, despite various episodes of road building to provide employment during the Depression, and despite some urban road improvements through the Works Project Administration of the 1930's, most of the road-building emphasis was still two-fold: farm-to-market roads and primary highway systems that connected major cities. In 1941, there were 29.5 million automobiles using these roads.

But then in 1941, Congress passed the Defense Highway Act, the purpose of which was to identify which existing or needed highways would be helpful in times of national emergency and to fund their improvement or construction with 75% of federal dollars. This Act was expanded three years later to provide for what is still known as the ABC system of federally funded roads: A for interstate high-

ways, B for alternate or secondary highways, and C for arteries connecting both A and B to urban areas. The road-building craze was on. States clamored and competed for their share of the federal dollar. Automobile, labor, real estate, and petroleum groups enthusiastically supported the construction of ever more roads. Senator Case of New Jersey was quoted as saying in 1955 that the 52 million automobiles in the United States at that time didn't have **half** enough roads to travel on! In 1956, when the massive federal Interstate System was conceived, on a 90%-10% funding ratio—with the states paying only 10%—a projected $27 billion was at first thought sufficient to do the job by 1971, with $15 billion apportioned for more urban roads and connectors, and $12 billion for more rural roads or connectors. Enactment of the Highway Trust Fund in the same year, a bill that was supposed to expire in 1972, levied a tax on the purchase of motor vehicles, oil, gas, and auto parts, and put the money into a special federal account that was earmarked to help support the Interstate System.

In 1968, another law added 1500 miles to the originally planned 41,000 miles of the Interstate System, authorized the state highway departments to offer as much as $5,000 above the appraised value of a house or land area to encourage owners to sell, and set aside additional funds to construct off-the-Interstate parking or rest areas. The **Student Resource Booklet** describes the condition of the Interstate System nationally: it was two-thirds completed by 1975, had cost $35 billion by that time, and is expected to contain when completed a total of 42,500 miles. There is not space enough in this Guide to give a state-by-state story of conflicts that surround the continuing construction of the Interstate System in America today. Find out the road building story in your area and discuss it with your students. They will find it significant to determine the future of the automobile in terms of where and how they live now, identifying present realities in terms of population and land use, life style, and economic priorities.

Activity Card 1 – Computing Automobile Pollution

By completing Activity Card 1, the students will be able to see that—since large cars use more gasoline, they pollute more; if a poorly tuned automobile consumes more gasoline, it also pollutes more; if air conditioning and other accessories cut into gas mileage (and they do), then they too add to the air pollution.

The questions at the end of the card lead the students to make certain value judgments about their own needs and true concerns.

Activity Card 2 – Estimating the Carbon Monoxide in Your Area

Amounts of pollutants released into the atmosphere are usually computed in millions of tons per year for the entire country by methods which are based on averages. The students should realize that pollution is not produced at a constant rate, nor is it evenly distributed when it does occur. By following the procedure outlined on Activity Card 2, the students will see that, in the case of CO, the rate of production varies throughout the day, from day to day, and from place to place—even within their own community. It should be pointed out that because of this, air quality is difficult to monitor, and the direct effects of certain pollutants can be difficult to determine.

SECTION II EXAMINING THE FACTS TODAY

FOCUS

The two experiments for this section of the unit, **Worksheet 3, Home Heating and Pollution** and **Worksheet 5, Effects of Air Pollution on Seedlings**, will enable your students to determine for themselves that some fuels cause more pollution than others and that varying "doses" of polluted air have differential effects on living things. **Worksheet 4, Effects of Air Pollution on the Human Body**, has been supplied for the students to record the conclusions which they draw from reading and discussing the booklet article and seeing the two overhead transparencies.

You will probably want to emphasize throughout this section that polluted air does cause clothes to rot, metals to corrode, and paint to peel—but that the most serious threat by far is the impact which a noxious atmosphere has on living things. Students should be led to understand that the dramatic and tragic air pollution disasters, such as occurred in London, England in 1952 or New York City in 1966, are relatively few in number (thus far) and conspicuous in any study of air pollution. It is **prolonged exposure** to air pollution that we must worry about also, since it produces chronic health problems, especially in the respiratory and circulatory systems of the body. Two types of air pollution exist in many parts of our nation today—*intermittent strong but non-lethal doses* and *small, constant, and cumulative doses*, either of which can produce chronic health effects.

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
Soot, Smog, and Smell: How Much Harm Can They Do?	**Overhead Transparencies** The Respiratory System A Lethal Dose, The Temperature Inversion **Filmstrip 2** The Impact of Air Pollution **Audio Cassette, Side B**	**Worksheet 3** Home Heating and Pollution **Worksheet 4** Effects of Air Pollution on the Human Body **Worksheet 5** Effects of Air Pollution on Seedlings	**Activity Card 3** Effects of Air Pollution on Nylon **Activity Card 4** Effects of Ozone on Rubber **Activity Card 5** Particulate Distribution in Your Area

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Worksheet 3 – Home Heating and Pollution

Most air pollution is caused by the combustion of fossil fuel. Before you begin this experiment, you might like to have your students check the graph on Page 12 of their booklets. It gives a categorical breakdown of all air pollution that is

caused by combustion: Motor Vehicles—60%, Industry—17%, Power Plants—14%, Space Heating—6%, and Refuse Disposal—3%. Be sure the students understand that this graph shows the *combustion* picture only, that air pollution is also caused—though usually in small amounts—by natural causes such as dust storms. You can go from brief perusal of the graph to discussion of what a fossil fuel is; ask the students to name three. You might also like to ask the class for what purposes these fuels—coal, oil, and natural gas—are burned in private homes, apartments, or schools. Although the electricity that gives us light and air conditioning may have been generated by the burning of fossil fuel in a power generating plant, most of the fossil fuel consumption in private homes and public buildings is for space heating. Distribute copies of Worksheet 3 and proceed with the experiment.

This activity might be conducted by the entire class or by two or three students in front of the class. However you decide, each student should have a copy of the worksheet so that he or she can closely follow the procedure, record some observations, and answer the questions. The sample of coal might be obtained locally from a fuel company, and the sample of oil from a custodian in your own building. While conducting this demonstration, be aware that air currents and drafts could deflect the pollutants away from the porcelain.

After the students have completed their observations and answered the questions, go over the answers orally. Answers to the four questions will enable the students to see why natural gas is the most popular fuel for space heating at the present time, since alternative clean-burning methods for producing heat in our homes—such as solar energy—have not yet been developed to the point of wide commercial availability. As a result, we are rapidly depleting our reserves of natural gas. In fact, in some areas of the country today, such as in New Jersey, a shortage of natural gas has reached crisis proportions. You might also wish to point out that although solid coal pollutes more than natural gas, some methods are being developed for turning coal into a less polluting gas. Various conversion processes called "gasification" are producing fuels that are being tested today for prospective commercial use.

Ask the students, "**Why** did the natural gas burn more cleanly than the other fuels?" Their answers will probably be of this type:

> Gas mixes better with air.
>
> Gas is colorless to start with.
>
> Gas burns better than solids or liquids, since it weighs less.
>
> Coal and oil produce specks and drops that can be carried upward by the flame.
>
> Coal and oil could contain materials which are not consumed by burning.

Record all their suggestions on the chalkboard, and when the students are finished, encourage them to begin the reading of the **Booklet Article—Soot, Smog, and Smell: How Much Harm Can They Do?** since it begins with a further explanation of fuel combustion.

Booklet Article – Soot, Smog, and Smell: How Much Harm Can They Do?

When discussing this article, ask the class to recall the smells which issued forth from the various burning fuels. Ask if they noticed any other effects on their bodies such as burning or tearing of the eyes, or coughing. Ask whether they think prolonged inhalation of smoke from burning coal or oil would seriously affect an otherwise healthy person. Since their reading has informed them that **incomplete** combustion causes air pollution, the students should know at this point that coal and oil do not burn as cleanly as natural gas, since a portion of each of these fuels is released **unburned** into the atmosphere.

Both the teacher and the students should consistently read in words the abbreviations used for chemical compounds. Read "oxygen" for O_2, and "carbon monoxide" for CO, etc.

As you discuss the next area of concern in this article, "Identifying the Harmful Pollutants," be sure to correlate each with its effects on the human body. Use of the **Overhead Transparency, The Respiratory System** will be helpful for this purpose.

Overhead Transparency – The Respiratory System Show the overhead and provide the following information as you discuss each of the pollutants and its overall impact.

Asthma is a response of the air passages to irritating substances. An attack consists of a muscle spasm in the walls of the bronchioles and a thickening of the mucous lining of the bronchioles.

Bronchitis occurs when excessive mucous is produced in the bronchi and a recurrent or prolonged cough results.

Emphysema is usually associated with bronchitis either concurrent with that affliction or as a follow-up to it. Because of the large quantity of mucous in the branches of the bronchial tubes, air becomes trapped in the alveoli. This trapped air can cause the alveoli to enlarge and their walls disintegrate. Since the alveoli are the places in the body where gaseous exchanges between the atmosphere and the blood take place, emphysema is a very serious disorder.

Lung Cancer occurs when the mucous cells that line the bronchial tubes begin to divide and multiply in a rapid and disorderly fashion. Because lung cancer destroys healthy tissue and blocks lung passages, it is often fatal.

Booklet Article (continued)

Explanation of "The Sources" concludes this article. The sources are identified and described in the order of their **decreasing** contribution to the pollution of the atmosphere. The sources are also seen (in the graph) in proportion to each other. The **Overhead Transparency, A Lethal Dose, The Temperature Inversion**, is appropriate for use, as discussion of the booklet article culminates.

Overhead Transparency – A Lethal Dose, The Temperature Inversion The worst air pollution disasters in the world in terms of human fatalities, occurred between 1950 and 1966. They all occurred during the winter months in the northern temperate zone, specifically in areas of large population and industrial development. The chart below itemizes them for you, and gives the number of fatalities from each episode that are directly attributable to air pollution.

When	Where	Fatalities
Dec., 1952	London, England	4,000
Nov., 1953	New York, U. S.	250
Jan., 1956	London, England	1,000
Dec., 1957	London, England	750
Dec., 1962	London, England	700
Jan./Feb., 1963	New York, U. S.	300
Nov., 1966	New York, U. S.	170

In each case, the air pollution disaster resulted from meteorological conditions that caused the formation of a **temperature inversion**. The overhead illustrates both normal conditions and what happens during a typical inversion, when pollutants become trapped in a stagnating air mass under a shallow lid of warm air. Mention to the students that the worst such disaster—London, England in 1952—was one in which there was almost no air movement either horizontally or vertically for three days, and yet during this time space heating and industrial and power plant production continued unabated and the pollutants that were released into the atmosphere remained suspended there for everybody to breathe in. The students may be somewhat relieved if you mention to them at this point that *air pollution alert networks* have been established both nationally and internationally to help avoid the recurrence of such extreme disasters.

Worksheet 4 – Effects of Air Pollution on the Human Body and Filmstrip – The Impact of Air Pollution

As you distribute copies of this activity sheet, ask the students whether they can complete it without checking back in their booklets for information. Allow a few minutes for everybody to record as many facts as he or she can remember. You can then suggest that the worksheet be completed (for homework, perhaps) using their booklets again and/or information which the second filmstrip of the unit will supply.

The filmstrip shows how the respiratory and the circulatory systems of the human body are affected by polluted air. It emphasizes the importance of maintaining a clean atmosphere in order to eliminate the **chronic health problems** that come from breathing "just a little polluted air all the time." The visual also tells the student that polluted air can damage the eyes, the brain (hence the nervous system), the stomach lining (through contaminants in the food we eat), and that some doctors even trace premature baldness to persistent smog in the atmosphere. It concludes with a run-down of the other effects of air pollution, in economic and aesthetic terms. When students discuss the filmstrip, the point should be made that polluted air adversely affects both living and nonliving things; animals and plants as well as human beings are damaged by pollutants. The students will discover for themselves in the last activity of this section how young plants, in this case seedlings, can be damaged by air pollution.

Worksheet 5 – Effects of Air Pollution on Seedlings

So far, the effects of air pollution on the human body have been stressed. Students will now monitor the effects of polluted air on plants. Explain to the students that in order for them to obtain results *quickly*, they will be exposing seedlings to very polluted air. Because our atmosphere is **not** so polluted as the smoke that will issue from the test tube containing the splints, comparable results in nature would take longer to occur. You could mention, though, that the city of Saigon, which is one of the most polluted cities on our planet, has lost 19 out of every 20 living trees in recent years due to automobile pollution. In our own country, when a Connecticut farmer took his strange-looking spinach to a state agricultural specialist in 1967, the condition of his crop was diagnosed as *automobile blight*, caused by exhaust fumes. Further, in Cincinnati, Ohio, in 1968, about 2,500 pounds of sulfur dioxide escaped into the air from a burst pipe at a chemical plant, and people who had gardens in the area were told to destroy the fruits and vegetables which they had grown, because they were poisonous to eat.

As students introduce smoke to all the test tubes except the Control one, tell them to make sure that the rubber stoppers on the test tubes are loose enough to allow the "clean" air already in each tube to be displaced by the "polluted" air coming through the plastic tube. Have the students write descriptions of each seedling before and after the introduction of the smoke. After the students have made their observations, have them take down the apparatus and set the seedlings aside until the next day.

On the following day, before you simulate this process "in reverse" with **Worksheet 6, Cleaning Up the Air**, have the students observe their seedlings again. Let them compare new observations with those written the day before and then answer all the questions on Worksheet 5.

Note: The heating of wooden splints in this experiment creates smoke (particulates), tar (hydrocarbons), and carbon monoxide (CO). You will find that the tar is quite difficult to remove from the test tubes when the demonstration is over. It is suggested that all the glassware used with Worksheet 5 be stored after a simple rinsing and kept for Worksheet 6 or for the next time you conduct such an exercise.

Activity Card 3 – Effects of Air Pollution on Nylon

Synthetic materials are quite susceptible to the destructive forces of polluted air. Automobile tires and the insulation on wires crack and split, house paint discolors and peels off, and clothing made of synthetic materials such as nylon slowly deteriorates. This activity card outlines a procedure by which the students may test the affects of polluted air on nylon over a period of time.

Activity Card 4 – Effects of Ozone on Rubber

In order to dramatize to the class the effect of polluted air on automobile tires, a student may elect this activity. Advise the student to avoid looking directly into the sunlamp (ultraviolet lamp) while it is on. Also, some sunlamps are designed to generate heat as well as ultraviolet light. In order to eliminate the possibility that heat will contribute to the disintegration of the rubber band, try to obtain an ultraviolet light source which does **not** generate heat.

Activity Card 5 – Particulate Distribution in Your Area

Visible smoke and soot indicate that particulates are being released into the atmosphere. The absence of visible smoke or soot, however, does not necessarily indicate the absence of particulates. The procedure outlined on this card will demonstrate to the students that air which might **look** clean may be unclean and that the amount of air pollution varies considerably from place to place.

SECTION III PREVENTION TECHNOLOGY

FOCUS

There are several issues concerning the development and use of air pollution prevention technology. One frequently debated issue is ***who should pay for the research and development*** of better methods to monitor and control air pollution—the public (i.e., the federal government) or the polluters themselves—specifically, industries, power plants, and producers of automobiles. At the present time, over a third of the American dollars that are spent annually to maintain environmental quality, are spent on maintaining or improving the quality of the air we breathe. Note in Chart 1 below that the federal government's "share" of expenditures for air pollution control is relatively small at the present time. The bulk of the spending, both for research and for the purchase of marketed technologies, is by private enterprise and by the polluters identified above. Ultimately, such private spending is often passed on to the consumer. For example, Chart 2 illustrates how much more of the American family's income will be spent for electricity and for operating the family's vehicles in 1976 than in 1974 or 1975.

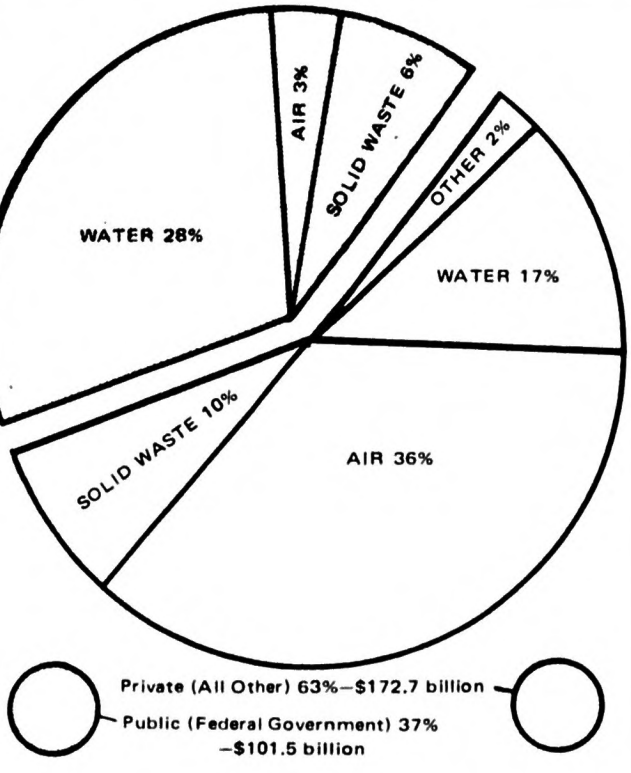
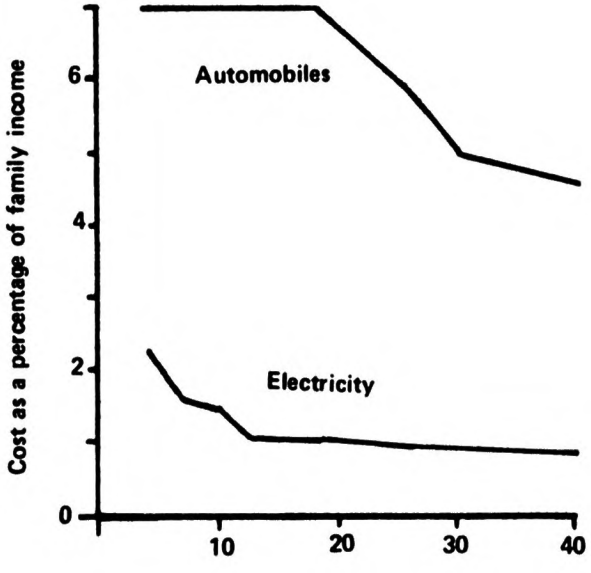


CHART 1: Distribution of Environmental Expenditures

CHART 2: Estimated 1976 Increases over 1974-75 Costs as a Percent of Family Income



Another key issue in this era of fuel shortages and costly energy is ***how the pollution prevention technologies affect fuel economy and efficiency***. Serious attention is being given today to the development of pollution prevention techniques that can also help to conserve our nation's energy resources. Description is given in this section of your Guide of some worthwhile **recovery** and/or **recycling** strategies that modern industries can implement as part of their air pollution control systems. In this section of the unit, students should come to realize that the cost of cleaner air is far less to us as a society than the cost of having polluted air.

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
Emission Control Devices for the Automobile **Pollution Control for Industries and Power Plants**	**Overhead Transparencies** The Catalytic Converter The Electrostatic Precipitator	**Worksheet 6** Cleaning Up the Air	**Activity Card 6** Emission Control Devices on Automobiles

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Booklet Article – Emission Control Devices for the Automobile

Before assigning the first article in this section of the unit, explain to the students that they do not have to be automobile mechanics in order to understand how pollution prevention devices work, nor do they have to be chemists. After the students have read the article, you might like to follow this procedure for reinforcing the content of the article.

On the chalkboard, construct a chart which has six rows down and four columns across. Encourage the class to refer to their booklets as they answer the following questions orally. "What are the names of the automobile air pollution control devices mentioned in the article?" As the devices are mentioned, list their full names in the left-hand column of the chart and label the column **Device**. Now ask, "Which pollutant(s) does each device help to control?" Write each pollutant next to the appropriate control device and label the second column **Pollutant**. Then ask, "How does each device control the pollutant(s)?" Write a brief description of the actual process next to the correct device/pollutant combination in the third column and label it **How Controlled**. Finally, ask, "Are there any special problems connected with the use of any or all of these devices?" If there are any, identify them in the fourth column and label it **Problems**. A typical line on the chart may read:

Device	Pollutant	How Controlled	Problem
HC-CO Converter	HC and CO	mixes exhaust with additional air and completes combustion with the aid of a platinum/palladium catalyst	lead in the fuel will coat catalyst

When the chart is complete, review it with the class, making sure that they understand terms like *HC* and *catalyst*.

Next, carefully erase all the lines and the headings which you used to make the chart. To the left of the former **Device** column write the word "The" before each device. Between each device and its pollutant write the word "controls." Between each pollutant and how

it is controlled write the word "by," and change the wording, if necessary, for grammatical accuracy. If there is a notation in the **Problem** column, separate it from the **How** column with the word "however."

Read through the sentences you and the class have put together and correct any grammatical inconsistences which may have occurred. Using this method, the example above becomes: **The** HC-CO converter **controls** HC and CO **by** mixes (mixing) exhaust with additional air and completes combustion with the aid of a platinum/palladium catalyst; **however**, lead in the fuel will coat the catalyst. Other sentences constructed by this procedure would be:

> **The** PCV valve **controls** escaped HC **by** sending the HC back to the combustion chamber to be burned.
>
> **The** Evaporation Emission Control device **controls** evaporated HC **by** sending them to the combustion chamber to be burned.
>
> **The** Exhaust Gas Recirculating System **controls** HO **by** sending exhaust gases into the combustion chamber to keep the combustion temperature low and prevent NO formation; **however**, this method reduces mileage.
>
> **The** air pumps **control** unburned HC and CO **by** mixing the hot exhaust gases with air so they burn further; **however**, the exhaust gases cool off very quickly.
>
> **The** NO converter **controls** NO **by** passing the exhaust gases over a nickle/copper catalyst to reduce the NO to nitrogen.

When all the sentences have been formed, have the students read them over again. Use this opportunity to answer any questions the students may have.

Overhead Transparency – The Catalytic Converter A showing of the overhead transparency, **The Catalytic Converter**, should follow class discussion of the article. You might like to make these points for the students as they see the visual:

1. Due to the presence of sulfur in petroleum products, automobiles emit sulfur oxide (SO) from their exhausts. Sulfur oxide combines with oxygen in the atmosphere and becomes sulfur dioxide (SO_2). Further oxidation produces sulfur trioxide (SO_3), which can combine with water vapor (H_2O) in the atmosphere to become sulfuric acid (H_2SO_4).

   Because an *oxidizing environment* is created by the HC-CO converter, automobiles with these devices produce SO_2 instead of SO. So, while the catalytic converter does not **increase** the production of sulfuric acid, it hastens it to some degree. This had led some people to cast a wary glance at the HC-CO converter, and to say that what we really need is development of a technology to remove the sulfur from the fuel **before** the fuel enters the gas tank.

2. Another point is that the NO converter has yet been developed to the point of having a catalyst life of 25,000 miles. This is the longevity which the Department of Environmental Protection has required.

Booklet Article – Pollution Control for Industries and Power Plants and Overhead Transparency – The Electrostatic Precipitator

Have the students read the booklet article. After this article has been read, ask your students to identify–either in oral discussion or in writing–(1) the two major types of pollutants that are emitted by industries and power plants and (2) the current technologies for controlling each of these major pollutants.

For example:

Pollutant	How Controlled
Gas (Sulfur dioxide)	1. Use of low sulfur fuels
	2. Exhaust gases pass through a spray of water and lime to eliminate sulfur dioxide
Particulates	1. Fabric filters act like large vacuum cleaners
	2. Electrostatic precipitator uses metal plates with negative charges to attract particulates which have been given a positive charge
	3. Wet scrubber sprays water into the dirty air to *catch* particulates and carry them away.

As you list the technologies for controlling particulate emissions, show the overhead transparency of the electrostatic precipitator. Three examples of pollution prevention technology are provided for your use here. Make the point for your students that the use of prevention technology does **not** always increase costs to the consumer. Here is what a few forward-looking industries have been able to do.

An industry in Ohio (the W. R. Grace Co.) installed a wet scrubber system consisting of 48,000 perforated plastic balls which absorb fine dust and ammonia vapor. During the first nine months of installation, more than $60,000 were saved in recovered products. Since the control device costs $102,000, it will pay for itself in about 15 months. Prior to control, the plant emitted 130 pounds per hour of fine dust into the atmosphere. The control device reduced the emission to 30 pounds per hour. Apart from the profitable recovery of the material, a significant contribution to cleaning the ambient air was made.

Another chemical company installed a dust collection system which recovers annually about 4,000 tons of fly ash. Since this material contains about 10 percent carbon it can be reused as fuel. Another plant of this same company installed a $5,000 control device to recover the foul-smelling benzothiazole. The company now recovers about $50,000 worth of this material a year.

One large utility plant that had been collecting fly ash in precipitators had to dispose of more than 1,000 tons daily at a disposal cost of $1.75 per ton. Now, a cindering plant pelletizes the ash and is able to sell it at $4.50 per ton. Prior to control, the plant had paid $1,750 per day disposal costs. Now the sold material brings $4,500 daily, amounting to a net profit of $6,250 per day, or $2,281,250 per year.

Worksheet 6 – Cleaning Up the Air

Two methods for reducing particulate emissions are the use of fabric filters and wet scrubbers. The activity outlined on this worksheet demonstrates the relative effectiveness of both methods when applied to smoke.

NOTE: Instead of using two pieces of glass tubing 3 inches long, you might wish to use the glass portion of two small bulb pipettes. This will eliminate the need for cutting and polishing the glass tubing.

Activity Card 6 – Emission Control Devices on Automobiles

This card encourages interested students to research for additional information concerning emission control devices, some of which were previously mentioned in the student booklet and some were not. A student with artistic ability might like to provide the class with diagrams illustrating each device or principle.

SECTION IV WHAT IS THE LAW? IS IT WORKING?

FOCUS

In this final section of the unit, students will learn what guidelines have been built into federal laws in order to promote air quality. They will learn that the federal government has set ***air quality standards*** for the protection of people's health and has required the states to develop and enforce ***implementation plans*** to achieve those standards. It is important for students to realize that while the federal government has the responsibility and the authority to enforce a pollution control program, the states and local governments are encouraged to assume the major role in actually cleaning up the air. Students will become aware of the need for effective air pollution laws at all levels of government.

In this section, the students will also evaluate the impact which can be made by the private individual and by citizen action groups. In addition, they will evaluate media reports in their booklets (facsimiles of newspaper articles) which give some reasons why the federal guidelines have not yet been fully implemented. As the teacher, you are encouraged to make your treatment of air pollution legislation as relevant and as timely as possible by engaging your students in monitoring their own community with the use of **Worksheet 8 – A Community Clean Air Checklist** and in evaluating up-to-date pollution information in the local media by using the criteria suggested in **Activity Card 8 – Evaluating Media Reports in Your Area.**

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
Air Pollution Legislation		**Worksheet 7** What Do Air Pollution Laws Cover?	**Activity Card 7** Air Pollution Research
The Clean Air Amendments Today		**Worksheet 8** A Community Clean Air Checklist	**Activity Card 8** Evaluating Media Reports in Your Area

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Booklet Article – Air Pollution Legislation and Worksheet 7 – What Do Air Pollution Laws Cover

Distribute copies of the worksheet and discuss it briefly with your students before assigning them to read the first of the two booklet articles in Section IV. You might like to have the class get into groups of three or four and classify the legislative "provisions" specified on the worksheet by group consensus. Each group should be encouraged to write at least two more provisions (for 14 and 15 on the worksheet) that good air quality laws should cover. When the groups have finished this activity, a consensus of the entire

class would be in order, so that discrepancies or differences among the groups can be noted and discussed. The students will find it helpful if you make statements such as this while they are engaged in the classifying activity, "The local government makes laws to deal with the problems that concern the community, the state laws deal with state problems, and the federal laws deal with interstate and national problems." It is also important to mention that some of the thirteen provisions that are listed are presently covered by more than one level of government; e. g., 2, 3, and 7, and that one of the items on the list (13) is not presently covered by legislative authority at all. Once these distinctions have been made (without telling the students the numbers) the students should classify the provisions according to the legislative level which they think is or should be responsible for them: local (L), state (S), federal (F), or any combination thereof.

Next the booklet article, **Air Pollution Legislation**, should be read; it provides a brief historical context for federal laws and identifies the major thrusts of each of the three legislative efforts which have been made at the federal level thus far in the United States. Be sure your students understand that the great variety of laws which exist at the state and local levels exist because the needs and priorities for air pollution control differ in various areas of our country. For example, city parking ordinances designed to reduce the use of the private passenger car in congested areas would seem irrelevant in a suburban or rural area, where zoning might be a necessary strategy for pollution prevention.

Worksheet 8 — A Community Clean Air Checklist

Distribute copies of **Worksheet 8**. So far in this unit the students have learned about the causes of air pollution, the chemical and economic effects of air pollution, the health effects of air pollution, and both technological and legislative attempts to control air pollution. A culminating activity for the unit is outlined on this worksheet.

This activity is designed to answer the question, "What exactly is my community doing to monitor, control, or prevent air pollution?" Students may want to interview local officials of government and industry as valuable sources of information in trying to answer their question 5. In order to get answers for all the questions on the worksheet most efficiently, it is suggested that you use the following procedure. Hand out **Worksheet 8**, and have the students read it. Ask for volunteers and choose those four whom you feel would perform responsibly. Assign one student to write to one of each of the following: a local branch of the Environmental Protection Agency, the Health Department, the Sanitation Department, and the City or Town Attorney. In their respective letters the students should zero-in on the specific questions indicated below:

- Local EPA Office: 2, 4, 5, 6, 7, 8, 9, 11, and 12.
- Health Department: 1, 2, 3, 4, 7, 8, 9, 10, 11, and 12.
- Sanitation Department: 9 and 10.
- City or Town Attorney: 1, 2, 3, 4, 6, 7, 8, 11, and 12.
- Local medium and heavy industries: 2, 3, 4, 5, and 8.

The students should also indicate that they will be grateful to receive responses from the person or agency they have contacted in any of these forms:

1. Written Statements

2. Taped Interview

3. Personal Appearance in Your Classroom

Other volunteers from the class should also be assigned, one each, to specific industries in your area. They may also follow the procedure outlined above.

When all available data has been obtained, encourage the class to **evaluate** the information they have gathered about their community. Make the point that citizens today should become increasingly aware of the decision-making roles they can play—in voting on community issues, in electing representatives to local government and policy-making bodies such as the board of education, and in asking informed questions of the right people. Concerned individuals of all ages can serve on advisory committees, join citizen action groups, and support good legislation directed at solving environmental problems.

If students ask what they as private, non-activist individuals can do in order to help prevent air pollution, you might cite activities such as these:

1. Avoid the open burning of leaves and trash.

2. Check the operating efficiency of automobiles and home heating facilities.

3. Refrain from over heating the home.

4. Decrease the consumption of energy, specifically of sulfur-containing fuels such as petroleum products.

If some "activist" students express an interest in correcting a specific air pollution problem that they have identified in their own community, offer them these guidelines:

1. Consider clearly what you want to have accomplished. What is your goal?

2. A team effort may be needed if you are to be successful in achieving your goal. Organizations in your town made up of concerned citizens may already exist; people may already be working to lessen air pollution. Find out the names of these groups. Join them. Begin your own group if none already exists.

3. Remember that every group needs strong individuals who will take charge and direct the actions of the group. One of the roles of the leader is to act as spokesman for the organization. Has the leadership been identified, or can leadership be provided?

4. Many facts must be known before you can decide what must be done. Additional information may also be necessary if legal action is to be taken against violators. Be sure you have the answers to questions such as these: Who is polluting? How? Where? When? Can the pollution feasibly be stopped immediately? Be stopped on a short-term basis? Be stopped on a long-range basis?

5. The problem you choose to investigate may seem simple at first, but it may be very complex once the facts are known. Therefore, before any meaningful action can take place, it may be necessary to consult with specialists who are likely to know the most about your topic. Whom would you consult about the problem you've chosen? What questions would you ask?

Activity Cards 7 and 8 — Air Pollution Research and Evaluating Media Reports in Your Area

Discussions of feasibility often raise many related considerations, such as the technological, social, or economic aspects of curbing a specific air pollution problem at its source. This point will be amplified for your students as they continue to evaluate what they read and hear in the media. The **Student Resource Booklet** material entitled **The Clean Air Amendments Today** should have primed your class for realizing this fact. For your convenience, here is an itemizing of points that have been brought out in the facsimiles of newspaper articles in the student booklet.

1. Postponement of installation of wet scrubbers due to time needed to implement the technology.

2. Postponement of state review of construction plans for sites which could potentially cause automobile congestion.

3. Postponement of emissions standards for power generating companies due to the energy crisis.

4. Objection to the enforcement of emissions standards by a steel company, which threatens the loss of 2,700 jobs.

5. Complaints about the increased costs of new automobiles due to pollution prevention requirements.

6. Conflicting points of view (i.e., the last two articles) concerning industrial changeover from oil to coal.

You should also encourage students to bring current articles and reports about air pollution to class and discuss them, correlating new information about research, legislation, etc. with the information they have already read.

KIT INVENTORY FOR AIR POLLUTION AND YOUR HEALTH

1 Teacher's Guide
30 Student Resource Booklets
10 Ecomasters (8 Activities and the 2-page Unit Test)
4 Overhead Transparencies
8 Activity Cards
2 Filmstrips
1 Audio Cassette (recorded on Side A and Side B)

ANSWERS TO THE UNIT TEST

1. d	6. d	11. d	16. d
2. b	7. c	12. a	17. b
3. c	8. d	13. c	18. c
4. d	9. d	14. b	19. d
5. a	10. d	15. d	20. c

SECTIONS OF THE UNIT	STUDENT RESOURCE BOOKLET	COMPONENTS TO COORDINATE WITH RESOURCE BOOKLET		
		Audio-Visual Materials	Ecomaster Activities	Extension Activities
Clarifying Issues and Values	**Preface to the Unit, Seeing Issues as Human Values** **The Future of the Automobile**	**Filmstrip 1** A Story of Air Pollution **Audio Cassette Side A**	**Worksheet 1** Air Pollution Problems **Worksheet 2** Automobile Air Pollution	**Activity Card 1** Computing Automobile Pollution **Activity Card 2** Estimating the Carbon Monoxide in Your Area
Examining the Facts Today	**Soot, Smog, and Smell: How Much Harm Can They Do?**	**Overhead Transparencies** The Respiratory System A Lethal Dose, The Temperature Inversion **Filmstrip 2** The Impact of Air Pollution **Audio Cassette Side B**	**Worksheet 3** Home Heating and Pollution **Worksheet 4** Effects of Air Pollution on the Human Body **Worksheet 5** Effects of Air Pollution on Seedlings	**Activity Card 3** Effects of Air Pollution on Nylon **Activity Card 4** Effects of Ozone on Rubber **Activity Card 5** Particulate Distribution in Your Area
Prevention Technology	**Emission Control Devices for the Automobile** **Pollution Control for Industries and Power Plants**	**Overhead Transparencies** The Catalytic Converter The Electrostatic Precipitator	**Worksheet 6** Cleaning Up the Air	**Activity Card 6** Emission Control Devices
What is the Law? **Is It Working?**	**Air Pollution Legislation** **The Clean Air Amendments Today**		**Worksheet 7** What Do Air Pollution Laws Cover? **Worksheet 8** A Community Clean Air Checklist	**Activity Card 7** Air Pollution Research **Activity Card 8** Evaluating Media Reports in Your Area